



FACULTY OF HEALTH

The relationship between the preferred rate of movement and the most optimal cadence in the skill of cycling

by

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Certificate of Authorship and Originality of Thesis

I certify that the work in this thesis has not previously been submitted for a degree nor has it been submitted as part of the requirements for a degree except as fully acknowledged within the text.

I also certify that the thesis has been written by me. Any help that I have received in my research work and in the preparation of the thesis itself has been acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

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Anthony Gerard Whitty

30/10/2017

Date

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List of Publications

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2. Whitty, A. G., Murphy, A. J., Coutts, A. J. & Watsford, M. L (2016). The effect of low- vs high-cadence interval training on the freely chosen cadence and performance in endurance-trained cyclists. *Applied Physiology, Nutrition and Metabolism*. 41 (6):666-673.
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2. Whitty, A. G., Murphy, A. J., Coutts, A. J. & Watsford, M. L (2014). The training effect on the freely chosen cadence, optimal pedaling frequency and

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Preface

This thesis for the degree of Doctor of Philosophy is in the format of published or submitted manuscripts and abides by the ‘Procedures for Presentation and Submission of Theses for Higher Degrees – University of Technology, Sydney; Policies and Directions of the University’. All manuscripts included in this thesis are closely related in subject matter and form a cohesive research narrative.

Based on the research design, four manuscripts have been submitted for publication, with two having been accepted and published in peer-reviewed journals. These papers are initially brought together by an *Introduction*, which provides background information, an extension overview of the literature pertaining to all aspects of the thesis, and defines the research problem and the aims of the series of studies. The *Literature Review*, which is formed as a publication, provides a specific overview of previous knowledge regarding the relationship between the preferred rate of movement and the most optimal in locomotive skills. This review also provides a summary of the literature pertaining to the selection of the preferred pedalling rate in cycling.

The body of the research is presented in manuscript form (*Chapter 3 to Chapter 5*), in a logical sequence following the development of research ideas in this investigation. Each manuscript separately outlines and discusses the individual methodology and the findings of each study. The *Discussion* chapter provides an interpretation of the collective findings and practical applications from the series of investigations conducted as part of the thesis. This chapter also suggests directions for future research.

Abstract

Research examining the relationship between the preferred rate of movement and the most optimal in locomotive sports has demonstrated that both novice and well-trained participants select a preferred rate of movement that minimises the metabolic demands of the task. Referred to as the metabolic demand hypothesis, it has been suggested that novices will initially produce a movement pattern that is unstable, inaccurate and high in metabolic demand when compared to a well-trained participant. However, after a period of practice, novice participants will adopt a refined movement pattern with increased metabolic efficiency and reduced internal mechanical work required to coordinate and control the limbs.

In cycling, the preferred rate of movement is commonly referred to as the freely chosen cadence (FCC). Previous cycling research has demonstrated that elite and novice cyclists select a FCC that is significantly higher than the most optimal metabolic cadence. Instead, the FCC may be attributed to mechanisms other than the need to minimise the metabolic demands of the task, such as mechanical, psychological or physiological factors. However, other cycling studies have shown that the optimal metabolic cadence in well-trained cyclists increased as power output was elevated at higher exercise intensities and more closely resembled the FCC than previously shown. Therefore, to date, there remains conflicting findings as to whether the skill of cycling adheres to the metabolic demand hypothesis and exactly what variables directly influence cadence selection.

The aims of this thesis were to firstly determine whether the skill of cycling adhered to the metabolic demand hypothesis. Secondly, if this was not the case, the research

sought to investigate variables or mechanisms responsible for influencing cadence selection. Finally, the research aimed to determine the impact of a specific cadence-based interval training protocol on the FCC and performance. These aims were investigated using separate studies.

In study 1, a group of non-cyclists completed a series of tests at varying workloads, measured in relative terms of each participant's fitness level, to determine their FCC and optimal pedalling frequency. The findings revealed that non-cyclists preferred to cycle well above the most optimal metabolic cadence, possibly in order to decrease muscle strain and mechanical load rather than the need to minimise aerobic demand.

In studies 2 and 3, non-cyclists and well-trained cyclists completed a 6-week cadence-based interval training program to determine whether the FCC could be altered with specific training. These studies were also conducted to determine if the selection of the FCC in both cohorts was related to minimising the metabolic demands of the task, and to assess the impact of the interval training program on performance. Collectively, the findings from these studies demonstrated that both well-trained and non-cyclists selected a FCC that was significantly higher than the most metabolically optimal cadence suggesting that the skill of cycling did not adhere to the metabolic demand hypothesis. Unlike other cycling research, the findings from these studies did not support the notion that cadence selection was solely based on minimising muscular effort or reducing the perceived exertion of the task. However, the findings were able to provide evidence to suggest that cycling cadence selection is different to other locomotor activities and may be under the control of central pattern generators (CPG). This was evidenced by the fact the FCC was highly

individualised, recorded strong between-day reliability in all participants, and was shown to be impacted by internal and external factors such as increases in power output and mechanical loading. The findings from studies 2 and 3 also revealed that regardless of the training stimulus, both well-trained and non-cyclists preferred to pedal at higher cadences and that low cadence interval training has the potential to have a greater impact on performance outcomes than high cadence training.

List of Abbreviations

beats·min⁻¹ : beats per minute

DP_{bot}: bottom dead point of the crank cycle

DP_{top}: top dead centre of the crank cycle

FCC: freely chosen cadence

GE: gross efficiency

NE: Net efficiency

WE: Work efficiency

DE: Delta efficiency

iEMG: integrated electromyography

m: metres

min: minutes

n: number

VO_{2max}: maximal oxygen uptake

RE: running economy km·h⁻¹ – kilometres per hour

RPE: rating of perceived exertion

RPM: revolutions per minute

T_{0deg}: torque at 0°

T_{135deg}: torque at 135°

T_{180deg}: torque at 180°

T_{45deg}: torque at 45°

T_{90deg}: torque at 90°

T_{mean}: mean torque

T_{peak}: peak torque

W_{max}: maximal work capacity